

Revision date: February 20, 1997

Hydrogen basic research - see Volume II, pages 1-14 and 1-56

Biomass power R&D - see Volume II, page 1-7

Photovoltaics R&D with U.S. companies, such as this cadmium telluride array from Solar Cells, Inc. - see Volume II, page 1-2

Solar thermal electric R&D - see Volume II, page 1-10

The National Wind Technology Center, located at NREL, conducts research and development of wind turbines and related technologies in cooperation with U.S. companies and other laboratories. This turbine from Advanced Wind Turbines is undergoing performance testing at the Center. (Photo - Warren Gretz, NREL) - see Volume II, page 1-5

Advanced vehicle R&D - see Volume II, page 1-25

Resource assessment research - see Volume II, page 1-20

Alternative fuels utilization R&D - see Volume II, page 1-27

Biofuels R&D - see Volume II, page 1-23

Building energy and electrochromics R&D - see Volume II, page 1-35

Solar buildings R&D - see Volume II, page 1-12

Industrial process R&D - see Volume II, page 1-38

# Preface

The NREL Institutional Plan FY 1997 – FY 2002 pulls together into one document a summary of results of NREL's complete planning processes: strategic planning, operational planning, setting of performance measures, and budgeting. These processes occur at all levels of the Laboratory, including the Laboratory corporate level, the center or organizational level, the program level, the team level, and the individual contributor level.

The Institutional Plan is intended first of all for our major customer, the U.S. Department of Energy (DOE). Therefore, this document describes future directions at the corporate Laboratory level and at the major DOE program level, along with key administrative functions, but does not include specific center-, team-, and individual-level plans.

The Institutional Plan also provides an overview of the Laboratory and its future directions for other major NREL stakeholders, including other national laboratories, industry and business partners, universities, other government agencies, and the public. Lastly, the Institutional Plan describes the linkage of NREL's planned activities to national goals and DOE's strategic directions.

This Institutional Plan differs from earlier plans by being offered in two volumes:

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Copies of the *NREL Institutional Plan FY 1997 – FY 2002* (Volume I, Volume II, or both) can be obtained through NREL's External Relations Office. Comments on the Plan may be addressed to:

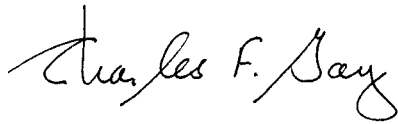
National Renewable Energy Laboratory  
Office of the Directorate  
1617 Cole Boulevard  
Golden, Colorado 80401

# Message from the Director

*The National Renewable Energy Laboratory (NREL) is a key contributor to the U.S. Department of Energy (DOE) effort to secure a sustainable energy supply for the nation. NREL serves as the DOE's lead laboratory in developing renewable energy technologies and a primary laboratory for developing energy efficiency technologies.*

*The NREL Institutional Plan describes the basic principles that the Lab uses to guide its work. The Plan defines the Lab's strategic framework for setting goals, allocating resources, and managing its operations, and identifies performance measures for objectively evaluating the Lab's progress. The Plan is intended to serve as a foundation upon which Lab personnel build their specific research, development, and deployment programs, and through which others can come to better understand NREL's work.*

*With NREL's leadership, renewable and energy efficiency technologies have made tremendous strides forward in improved performance, reliability, and cost competitiveness. With NREL's assistance and collaboration, the U.S. renewables and efficiency industries have grown rapidly and have secured leadership positions in international energy markets. The NREL Institutional Plan outlines the Lab's strategic framework for continuing this success.*

A handwritten signature in black ink, reading "Charles F. Gay". The signature is written in a cursive style with a large, stylized 'C' and 'G'.

Charles F. Gay

# Laboratory Overview

The National Renewable Energy Laboratory (NREL) was established by the Solar Energy Research, Development, and Demonstration Act of 1974 as a national center for federally sponsored solar energy research and development. Originally called the Solar Energy Research Institute when it opened in 1977, the name was changed in 1991 when NREL received national laboratory status, joining the nine other DOE national laboratories. NREL is the only single-program national laboratory in the DOE system; all other national laboratories are multiprogram laboratories.

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## NREL's Mission

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**Lead the nation toward a sustainable energy future by developing renewable energy technologies, improving energy efficiency, advancing related science and engineering, and facilitating commercialization.**

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## ***Basic Principles***

The success of every organization rests on its basic principles. The principles upon which NREL bases its operations and activities are listed below:

- Everything we do is driven by our mission.
- Our primary focus is to advance R&D for—and facilitate the deployment of—renewable energy and energy efficiency technologies.
- We assist with energy solutions that support sustainable development and mitigate environmental problems.
- We push the leading edge in integrating science and technology.
- We work in partnership with other laboratories, U.S. industry, academia, and energy end users.
- We serve as the world's leading and most comprehensive center of renewable energy and energy efficiency science and technology, acknowledging the important strengths and contributions of our partners.
- We use our resources effectively to achieve world-class laboratory operations.

In partnership with U.S. companies, NREL's process development unit evaluates biotechnology processes to produce ethanol and other fuels and chemicals—the only facility of its kind in the United States. (Photo - Warren Gretz, NREL)

- We are committed to providing the best possible working environment to help our staff achieve excellence, including strong programs in environment, safety, and health.

Each of these basic principles is confirmed in the following sections describing the Laboratory today.

## ***Mission and Focus***

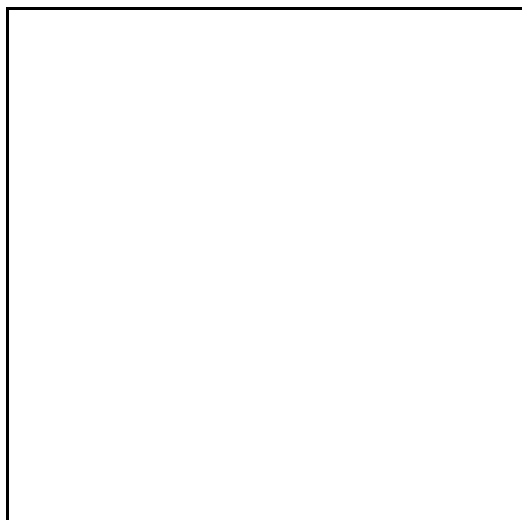
NREL is the nation's lead laboratory for developing renewable energy technologies, and is a primary laboratory for developing energy efficiency technologies.<sup>1</sup> This single focus is emphasized in NREL's mission: Lead the nation toward a sustainable energy future by developing renewable energy technologies, improving energy efficiency, advancing related science and engineering, and facilitating commercialization.<sup>2</sup> The Laboratory provides leadership in the development of scientific understanding and new technologies through service to DOE and the nation.

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**NREL's core capabilities focus on renewable energy and energy efficiency technology development.**

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NREL's core capabilities also focus on renewable energy and energy efficiency technology development. The first three capabilities relate to the Laboratory's technical strengths, while the last capability supports NREL's role in facilitating commercialization of these technologies:



One of NREL's core capabilities is advanced materials science. Here an NREL researcher conducts R&D on deposition of photovoltaic materials. (Photo - Jim Yost, NREL)

- Development and characterization of renewable energy technologies, energy efficiency, and waste conversion processes and technologies
- Advanced materials science, engineering, and characterization
- Systems and process engineering and integration for renewable energy and energy efficiency technologies
- Partnerships for technology development for renewables and energy efficiency technologies.

NREL's strengths in science, technology, and program management result directly from the Laboratory's exceptional scientific, engineering, and administrative staff, totalling about 700 regular employees and dozens of visiting researchers from around the world who work at NREL each year. NREL's facilities are also strong assets that support the Laboratory's unique mission, with several new state-of-the-art technical facilities that have been constructed recently with DOE capital funds. NREL's staff and facilities are discussed more thoroughly in Volume II.

## ***Energy Solutions for DOE and the Nation***

Stable, clean energy supplies are essential to the security and prosperity of the nation. At present, American utilities rely on low-cost fossil fuels to provide most of the energy for industry and buildings. With petroleum imports now surpassing the 50% mark, the nation is at ever-greater risk for disruption of vital fuel supplies for transportation. At the same time, as the environmental impacts of fossil-fuel extraction, conversion, and use become greater concerns, the nation is faced with the fundamental challenge of how to ensure a sustainable energy future.

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**Renewable energy and energy efficiency technologies are core components of a diverse energy-source portfolio.**

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The federal government addressed this challenge in *Sustainable Energy Strategy*, in which it defined the country's energy policy plan by setting the following national goals:

- Maximize energy productivity to strengthen our economy and improve living standards
- Minimize pollution to reduce the adverse environmental impacts associated with energy production, delivery, and use
- Keep America secure by reducing our vulnerability to energy supply disruption and cost fluctuation.<sup>3</sup>

Renewable energy and energy efficiency technologies are core components of a diverse energy-source portfolio, as recognized in the report of the Secretary of Energy's Task Force on Strategic Energy Research and Development.<sup>4</sup> Notwithstanding current debates over near-term federal energy research and development (R&D) funding, there is emerging agreement that these technologies will be of critical importance to future energy supplies. Shell International, one of the world's major petroleum corporations, recently summarized its views on energy demands and markets as follows:

"There will be need and room for all in the energy markets of most of the 21st century." —Shell International. These solar troughs provide solar heat for hot water for a large prison facility. (Photo - Warren Gretz, NREL)

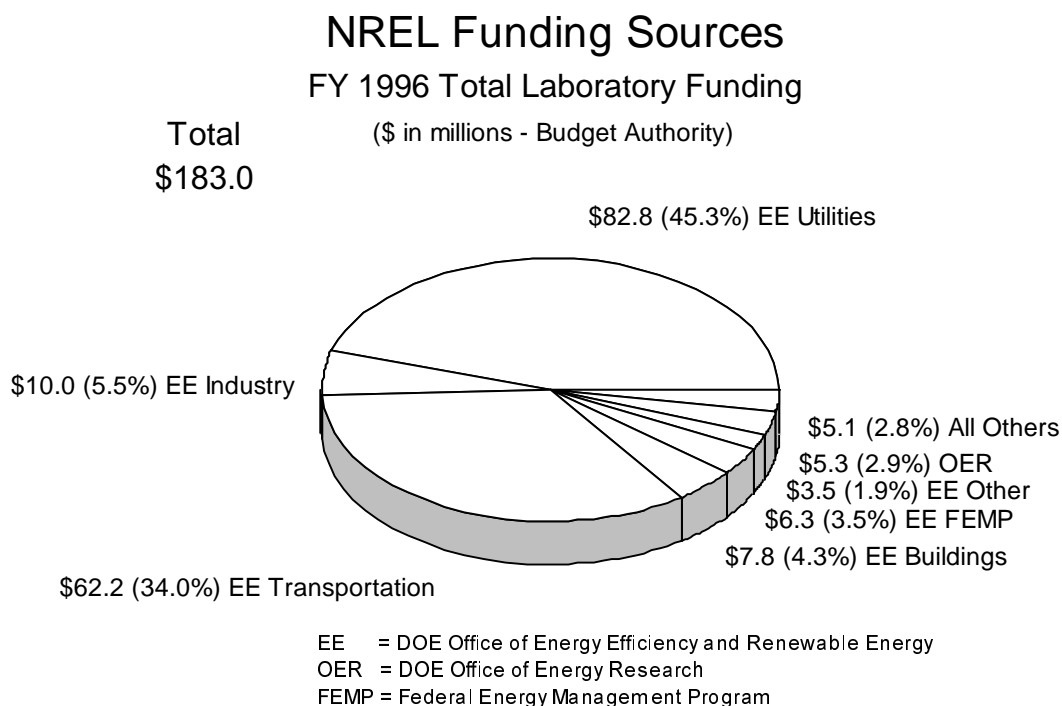
It soon becomes obvious to anyone who looks seriously at the question of how energy demand growth can be satisfied in the longer term that ... before too long renewable sources of energy will have to start to play an increasingly important role. We should, therefore, regard the stimulation of the development of new energy sources as complementary to the continued development of oil, gas and coal and not as a threat. There will be need and room for all in the energy markets of most of the 21st century.<sup>5</sup>

While the world confronts questions not only of energy use but of global climate change and prudent control of fissile nuclear materials, developing countries are increasing their energy consumption.

Urban air pollution and resulting health problems are plaguing more and more cities in the developing world. As energy markets transcend national borders and regional influences, renewable energy and energy efficiency technologies are playing an increasingly important role. Developing and marketing advanced energy technologies provide increasing leverage in ensuring national economic growth and industrial prosperity. America cannot afford to lose its position as the technological leader in sustainable energy technologies.

The U.S. Department of Energy (DOE) directs the federal government's investment in energy research and development. DOE describes four business strategies in its strategic plan, *Fueling a Competitive Economy*:<sup>6</sup> national security, environmental quality, energy resources, and science and technology. Given the descriptions of those areas in DOE's plan, virtually all of NREL's work supports the energy resources business strategy.

Renewable energy and energy efficiency technologies are key elements in achieving DOE's energy resource goals. Within DOE, the task of the DOE Office of Energy Efficiency and Renewable Energy (EE) is to manage the Department's investment in these technologies. EE is NREL's primary source of funds, and, in turn, NREL is EE's primary vehicle for accomplishing its mission.



The graph on the previous page indicates NREL's major funding sources for FY 1996.

NREL's ultimate customers are the future generations of U.S. citizens. We will serve those future generations best by serving our immediate customers well. NREL's immediate customers include DOE, U.S. renewable energy and energy efficiency companies, and energy end users such as utilities, U.S. industry, and the American public. As NREL's principal source of funding, DOE represents a very important customer or investor for the Laboratory. The adjacent box lists NREL's major customers and the DOE programs that NREL supports.

NREL is owned by the federal government, and is managed and operated for DOE by the Midwest Research Institute. Midwest Research Institute is committed to providing NREL with the effective management, the scientific and technical staff, and the cost-effective operations that the Laboratory needs to accomplish its mission.

### ***Pushing the Leading Edge***

Pushing the leading edge of science and technology is vital for NREL's success. Evidence of NREL's leading-edge technical achievements can be seen throughout Volume II of *NREL's Institutional Plan FY 1997 – FY 2002* in success-story sidebars and discussions of scientific and technical advances.

NREL's technical merit is regularly assessed through DOE program reviews, DOE/Office of Planning and Analysis reviews, and science and industry oversight committee reviews of specific program areas. More general measures include formal awards and publication citations. For example, NREL technical awards include 19 R&D 100 Awards, given out annually by *Research and*

#### **NREL's Major Customers and DOE Programs**

- Energy generators and consumers (including utilities, independent power producers, U.S. industry, and the American public)
- U.S. renewable energy and energy efficiency companies
- DOE/EE Office of Utility Technologies
  - Photovoltaics
  - Wind
  - Hydrogen
  - Solar Thermal
  - Biomass Power
  - Resource Assessment
  - Analytic Studies
  - Geothermal
  - Superconductivity
- DOE/EE Office of Transportation Technologies
  - Hybrid Vehicles
  - Biofuels
  - Alternative Fuels Utilization
- DOE/EE Office of Building Technology, State and Community Programs
- DOE/EE Office of Industrial Technologies
- DOE/EE Office of Federal Energy Management Programs
- DOE/EE Office of Budget, Planning and Customer Services
  - Analytic Studies
  - Technical Information
  - Information Services
- DOE Office of Energy Research



*Development* magazine to honor the year's 100 most significant technological advances. This is the highest number of awards per researcher in the DOE national laboratory system. In 1996 alone, two senior researchers at NREL were named Fellows in the American Association for the Advancement of Science and the American Society of Mechanical Engineers, and NREL researchers received three major awards for scientific and technical achievements from the U.S. Department of Energy and EUROSOLAR (the European association for the promotion of renewable energy).

To get an objective measure of the scientific and technical merit and influence of the national laboratories, the Institute for Scientific Information (ISI) recently published a study of the number of publications, and the number of times other researchers cited these publications, from each DOE multiprogram national laboratory.<sup>7</sup> NREL was not included in ISI's published study, but was included in ISI's database. Recognizing the value of this objective approach to judging scientific

## NREL—Building on Success

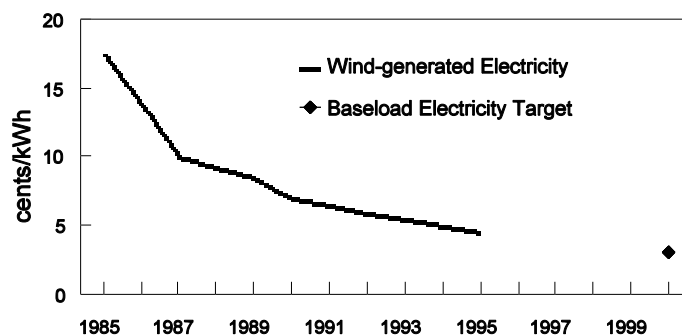
Throughout its existence, NREL has focused on its single mission to develop renewable energy and energy efficiency technologies. Advances in the scientific understanding of these energy areas, and application of our technology developments together with our industry partners, represent the unchanging foundation of our work.

Examples of these advances include repeated new records for energy conversion efficiency of photovoltaic materials, combined with greater fundamental understanding of these materials; advances in blade design and performance for wind turbines; significant progress in genetic engineering of enzyme-producing organisms for bioconversion of biomass and waste to alternative fuels; new methods for converting waste products to useful chemicals; advances in the science of whole buildings and indoor air quality; cutting-edge research on various photoconversion and energy storage processes; and improved understanding of the renewable energy resources of the United States and the world.

One measure of success is in the ability of an organization to set and meet technical goals. The adjacent figure shows the success of NREL, the U.S. wind industry, Sandia National Laboratories, Pacific Northwest National Laboratory, and other contributors in steadily lowering the cost of wind-generated electricity, heading toward the current target for the baseload cost of electricity.

Although great strides have been made in performance, reliability, and cost reductions for all renewable and energy efficiency technologies, continued innovation of new technologies is essential to their ultimate success and stability in the competitive marketplace.

Reduced Cost of  
Wind-Generated Electricity



Source: World Bank (1994) cost data

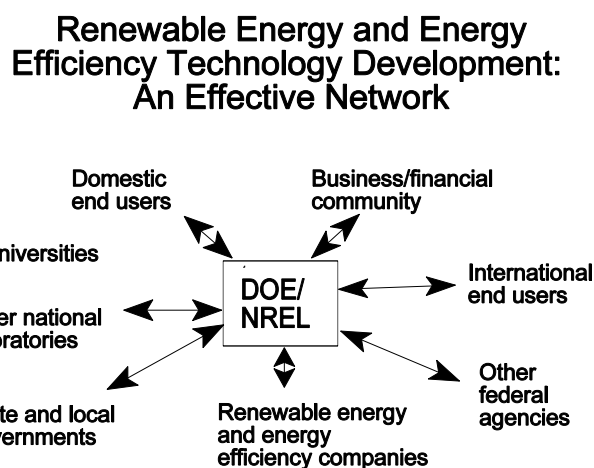
merit, NREL contracted with ISI to use its full database of statistics to analyze NREL's performance in comparison to that of other labs and to national averages.

These studies showed that in terms of publication productivity, 1981-1992, NREL produced more publications per researcher than any other national laboratory (above the statistical 95% confidence level) in the categories of environmental engineering/energy, and biotechnology/applied microbiology. In terms of influence on the scientific community for that period, NREL had more citations per paper than any other national laboratory (at or above the statistical 95% confidence level) in the categories of environmental engineering/energy, general physics, applied physics/condensed-matter physics, materials/metallurgy, and multidisciplinary scientific publications. The Laboratory has recently contracted with ISI to obtain data updated through 1995, and is in the process of updating this information.

### ***NREL as the Renewable Energy Hub in an R&D Network***

Part of the reason for NREL's technical success is that the Laboratory employs the largest collection of renewable energy and energy efficiency experts in the world. The synergy created by this group of experts working together is important to achieving leading-edge science and technology.

The principle of synergy applies to more than individual scientists collaborating within a lab. NREL is one of many entities involved in R&D of renewable energy and energy efficiency technologies. Because successful R&D requires collaborations among institutions with complementary capabilities, NREL sees itself as a hub in a network of laboratories, universities, companies, industry associations, business and financial institutions, government entities, and international leaders, all working to develop and further these technologies.



Strengthening partnerships with these organizations is one of NREL's key strategies for the future; these partnerships are further discussed in Volume I, Strategy 3 and in Volume II.

### ***World-Class Operations***

Maximizing the return on the nation's investment in NREL requires that the Laboratory achieve exceptional quality and cost-effectiveness in its operations. NREL is committed to an ongoing program of innovation and restructuring to improve its operations. In 1995 and 1996, NREL's self-initiated NREL 2000 reengineering project dramatically increased the Lab's operational efficiency. The efficiency improvements include: eliminating one to three layers of management; increasing

diversity among supervisory and management persons to 35%; implementing new systems for subcontracting that reduced cycle time by 48% and hourly costs by 20%; and implementing a credit card system for small purchases that reduced the transaction workload by 85% and the number of employees in the purchasing unit by 32%.

One of the key results of the NREL 2000 reengineering project was a new organizational structure for the Laboratory. A total of 24 centers and offices report to the deputy director. The new structure supports the DOE and NREL mission through organizing NREL's research and development capabilities into 12 centers of technical excellence. There are also 10 administrative centers and offices, and 2 centers to support the development of partnerships and new business ventures for the Laboratory.

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**One of the key results of the NREL 2000 reengineering project was a new organizational structure for the Laboratory.**

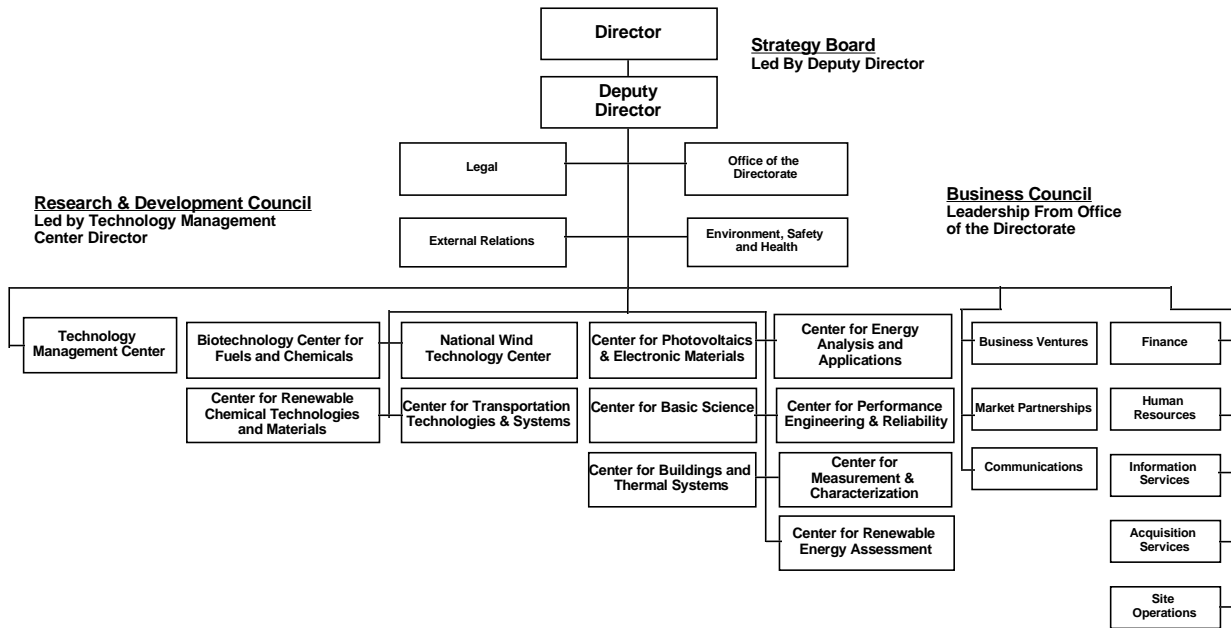
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This organizational structure was chosen to encourage cross-fertilization of ideas, fewer layers of management, team-based management at all levels, and more accountability at all levels of the organization. As one example of the practical working of this structure, some technical programs require resources from multiple centers. The technology manager who leads each program works with the required center directors to identify and commit the resources needed to carry out the work of the program.

NREL's flatter organization is intended to help teams form to serve cross-cutting needs, such as international projects. NREL researchers recently visited China to help the Chinese government with their interest in renewable energy, and visited a school on Hainan Island. (Photo - Simon Tsuo, NREL)

As another example of team-based management, three councils have important responsibilities in Laboratory management and leadership. Directors of technical centers constitute the R&D Council, which meets regularly to provide technical direction for the Laboratory. Directors of administrative centers constitute the Business Council, which meets regularly to provide direction for the Laboratory in administrative support areas. These two councils derive Laboratory strategic direction from the Strategy Board, made up of selected NREL leaders and chaired by the deputy director.

# NREL Organization



# Strategic Directions

NREL defines its strategies for achieving its mission around the strategic components of the nation's sustainable energy policy plan, which are to:

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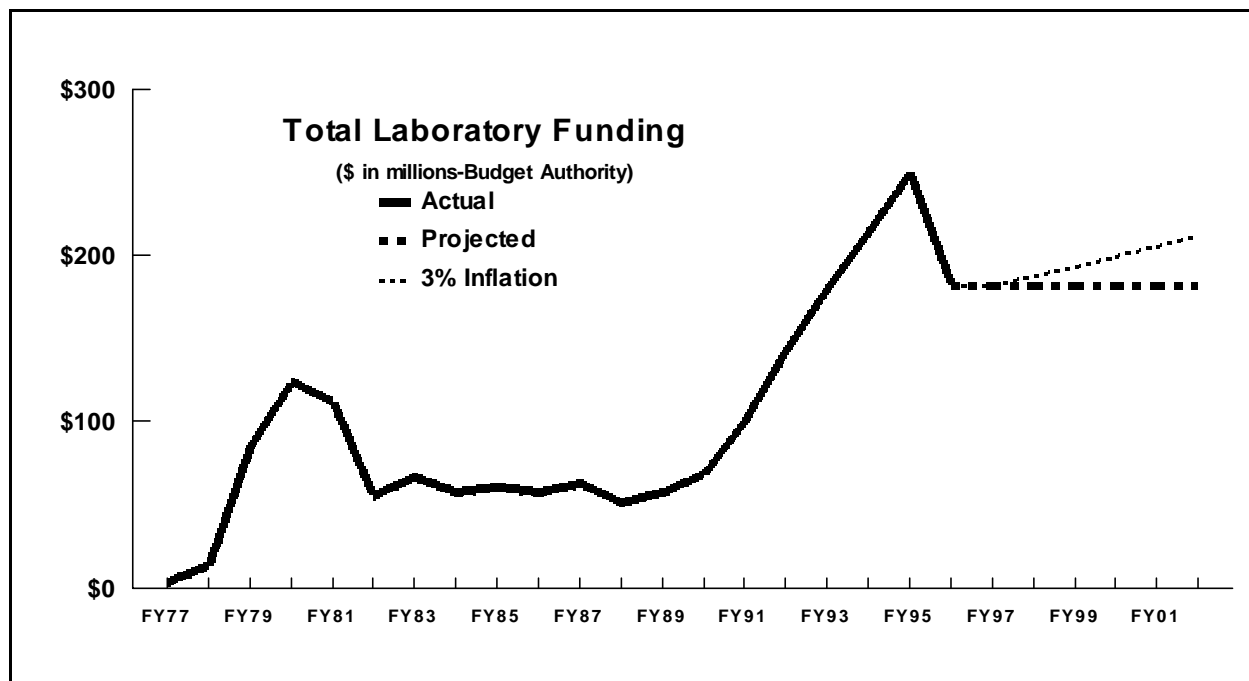
**NREL is the nation's lead laboratory for developing renewable energy technologies, and is a primary laboratory for developing energy efficiency technologies.**

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- Increase the efficiency of energy use
- Develop a balanced domestic energy resource portfolio
- Invest in science and technology
- Reinvent environmental protection
- Engage the international market<sup>8</sup>

NREL's leadership team met several times to discuss the issues facing the Laboratory today, and the strategic directions provided by DOE and others. Several of NREL's senior managers also met with EE senior managers. As a result of these discussions, NREL has determined that its major strategies for contributing to these national energy policy plan strategic components are to:

- Expand NREL's capabilities for research, development, and deployment assistance for DOE
- Support science and technology with world-class operations
- Strengthen integration of our work with others through partnerships
- Increase leveraging of EE funding



These major strategies form the core of NREL's Strategic Plan and guide NREL in directing its activities and managing its operations. In addition, these strategies are designed to achieve the Laboratory's mission and contribute to the nation's sustainable energy strategy. NREL does not expect to increase its budget authority during the next five years beyond the level of inflation, as shown in the preceding graph and following table. These strategies will be achieved by shifting priorities into new areas, expanding collaborations and partnerships, and where appropriate, increased leveraging of federal dollars from non-EE sources.

<b>NREL FUNDING</b>									
by Major Funding Source									
(\$ in millions--Budget Authority)									
	Fiscal Year*								
	1995	1996	1997	1998	1999	2000	2001	2002	
DOE Office of Energy Efficiency & Renewable Energy									
Operating									
Transportation Technologies	\$73.2	62.2	62.2	64.0	65.9	67.9	70.0	72.1	
Industrial Technologies	15.5	10.0	10.0	10.3	10.6	10.9	11.2	11.6	
Utility Technologies	117.9	79.3	79.3	81.7	84.2	86.7	89.3	92.0	
Building Technologies	10.8	7.5	7.5	7.8	8.0	8.2	8.5	8.7	
Federal Energy Management Programs	6.5	6.3	6.3	6.5	6.7	6.9	7.1	7.4	
Other EE	3.6	1.9	1.9	2.0	2.0	2.1	2.1	2.2	
Subtotal EE Operating	\$227.5	167.3	167.3	172.3	177.4	182.8	188.2	193.9	
Capital & Construction									
Program Capital Equipment	6.4	3.3	3.7	3.8	4.0	4.1	4.2	4.3	
Construction/GPP/GPE**	5.8	2.0	3.3	5.0	7.3	8.4	5.1	4.2	
Subtotal EE Capital & Construction	\$12.2	5.3	7.0	8.8	11.3	12.5	9.3	8.5	
Total EE Funding	\$239.7	172.6	174.3	181.1	188.7	195.2	197.5	202.4	
DOE Office of Energy Research	5.2	5.3	5.3	5.5	5.7	5.8	6.0	6.2	
All Others	5.5	5.1	5.7	5.9	6.0	6.2	6.4	6.6	
Total Laboratory Funding	\$250.4	183.0	185.3	192.5	200.4	207.3	210.0	215.2	
*FY 1995 and FY 1996 are actuals; FY 1997 is best estimate; FY 1998 and beyond are generally projected based on 3% inflation.									
** GPP = General Plant Projects; GPE = General Purpose Equipment									

### ***Strategy 1: Expand NREL's capabilities for research, development, and deployment assistance for DOE***

NREL serves as the focal point for most of DOE's renewable energy programs, and several energy efficiency programs. NREL must work with EE to ensure that these programs have the depth and breadth necessary to achieve the aims of DOE. NREL's mission extends from basic science research to systems development to facilitation of private-sector commercialization (deployment); NREL's

continued success in delivering on its mission requires that the Laboratory achieve an appropriate balance among its activities.

NREL has a sustained history of success in basic and applied research and development, as judged by frequent scientific peer reviews of NREL programs and the Laboratory's ultimate success in affecting the technologies that become commercialized. By working with its university partners, researchers at other national and international facilities, and DOE's Office of Energy Research, NREL will strive to ensure that basic and applied research "keeps the technology pipelines filled" with new concepts, new materials, new processes, and new devices to be developed with NREL's partners. The Laboratory will contribute to meeting the nation's need for basic research that continues to be deemphasized by industry in today's highly competitive business environment.

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**NREL recognizes the strategic need for a "center of excellence" . . . which provides all elements necessary to put a technology in place.**

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Research and development is the most successful when it results in the development of technology that is adopted by the private sector. Although U.S. companies bear the burden of commercialization, NREL contributes technical knowledge to help overcome system design and manufacturing problems; provides analyses of

NREL's Solar Energy Research Facility (left) and Outdoor Test Facility (right) are state-of-the-art laboratories that will be instrumental in the work of the National Center for Photovoltaics. (Photos - Warren Gretz, NREL)

market and economic issues; and brings together the technical, financial, and business interests for the synergy necessary to ensure the success of renewable energy and energy efficiency projects. Building on past successes in the Federal Energy Management Program, international development of renewable energy projects, and other areas, NREL will continue building its capabilities to serve EE across the full breadth of NREL's mission.

To meet the need for integrated, full-spectrum R&D programs in key renewable energy and energy efficiency technologies, NREL recognizes the strategic need for a central focus, or "center of excellence," for the technical work of these key programs. A center of excellence provides all

elements necessary to put a technology in place, such as a critical mass of technical staff with extensive depth and breadth of knowledge about the technology, scientific and engineering leadership and focus for all the technical contributors to a program (including other laboratories, industry, and universities), a central point for disseminating technical information, and specialized facilities for research and development.

This concept is not new; NREL pioneered the concept of technical centers of excellence with the National Wind Technology Center. NREL also worked with Sandia to spearhead the formation of SunLab, a "virtual" laboratory for solar thermal electric technology development. Building on that success, NREL intends to establish additional technical centers of excellence in the coming years.

Along with the centers of excellence, NREL will continue its current R&D programs, including its international leadership in wind energy technology development, and its activities to support hybrid vehicle development, industrial technology development, environmental technologies, and solar thermal technologies. NREL is considering centers of excellence in other technical areas; the initial strategic emphasis is on photovoltaics, while centers in biomass conversion and hydrogen are under consideration.

### **The National Center for Photovoltaics**

In November 1996, DOE established the National Center for Photovoltaics (NCPV) to be the focal point for developing technology and disseminating information about PV in the United States. The goal of the NCPV is to build on and to link the core set of facilities and expert staff at NREL and Sandia National Laboratories with additional resources in universities, industry, and other federal and state programs into a united effort to accelerate the advance of photovoltaics as an industry and energy source.

The NCPV will have the primary responsibility for implementing the National Photovoltaics Program by conducting research, development, and testing in partnership with the U.S. photovoltaic industry. The high visibility of the Center will enhance communication for those involved in PV and support outreach to those who seek technical information. Similarly, it can catalyze strategic partnerships and alliances among photovoltaic stakeholders and will also support drawing in new interests from industries whose financial resources, technology, or applications can augment the direct efforts of the PV industry.

The NCPV will provide the forum to enhance coordination and more clearly develop the vision and direction to assist industry in developing PV technology for the large-scale generation of economically competitive electric power and in making PV systems a significant contributor to the national and global energy mix.

## ***Strategy 2: Support science and technology with world-class operations***

As described in the Laboratory Overview section above, NREL has made major strides in the past 2 years in reducing its administrative costs and improving productivity. Much remains to be done, however. Key areas are summarized below; more detail can be found in Volume II.

**Human Resources:** Restructuring, reengineering, and downsizing require new approaches to employing, retaining, training, evaluating, and compensating Laboratory personnel. The Laboratory is reviewing its job structure, compensation system, and performance evaluation methods to bring



them into line with the new organizational structure and culture. The entire system of rewards and incentives will be reviewed to ensure agreement with the Laboratory's expectations for performance and strategic directions. Leadership training will continue, and team training is being developed for the entire staff. NREL also has a new program to foster creativity and innovation, which will provide the new ideas so critically needed to achieve our mission.

To strengthen NREL's position as a premier research institution, it is important to always seek opportunities to enhance our technical capabilities. For these reasons, NREL will explore selectively bringing in world-class researchers or technologists to help lead NREL toward its long-term goals. These additions could occur through various arrangements, including sabbaticals from universities,

consultants, visiting professional exchange programs with industry or other laboratories, or regular hires.

**NREL has made major strides in the past two years in reducing its administrative costs and improving productivity. Much remains to be done, however.**

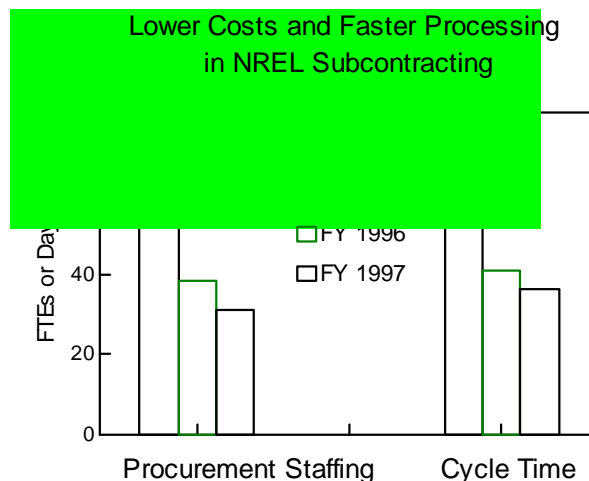
**Environment, Safety, and Health (ES&H):** NREL remains committed to strong programs to protect its employees, physical and

intellectual assets, the public, and the environment. These programs are developed and implemented according to risk-based criteria, whereby ES&H controls are matched to the hazards present to provide appropriate levels of control at a reasonable cost. The ES&H programs are also sufficiently flexible and responsive to accommodate the ever-changing nature of the work NREL conducts.

**Information Services and Technology:** NREL is evaluating options for restructuring its hardware and software architecture to streamline and upgrade its information systems. This restructuring is intended to lower costs through more standardization, and upgrade the quality of information available to the Laboratory by replacing or significantly improving the administrative computer systems.

**Facilities:** EE has supported the development of several new specialized facilities for NREL during the last few years, which have allowed for some reduction in lease costs and provided badly needed technical capabilities. The goals of NREL's capital improvement program remain, further reducing Laboratory operating costs and improving Laboratory operations efficiency by vacating leased facilities and consolidating operations into DOE-owned buildings on its two sites.

**Subcontract Management:** NREL has made great strides in lowering the cost and speeding the process of competing, awarding, and managing contracts, as seen in the adjacent graph. NREL intends to make further improvements by working with DOE Headquarters and the



DOE Golden Field Office to, for example, better identify the full costs of subcontract management and to clarify the roles and responsibilities of those in the subcontracting process so that subcontracts are handled more efficiently.

**Project Management:** NREL will implement improvements by using a "graded approach," streamlining planning documents, clarifying roles and responsibilities, developing a system of mentors, and instituting a much-improved information system for project managers.

### ***Strategy 3: Strengthen the integration of our work with others through partnerships***

In today's complex research and business environment, the combined strengths of different organizations must be brought to bear to further the missions of NREL and DOE. DOE directed its laboratories to be "integrated with the nation's R&D enterprise... [and to] be recognized as having strong, mutually supportive links to other agencies, universities, and industry."<sup>9</sup>

As a national laboratory, NREL's mission to lead the nation to a sustainable energy future cannot be achieved without synergistic partnerships with, among other institutions, U.S. renewable energy and energy efficiency companies, energy producers and users, state and local governments, universities, the finance community, international organizations, nongovernment organizations, and others. Current and planned emphases with these partners are summarized below, and discussed in more detail in Volume II on Partnerships.

NREL works with the U.S. automotive industry to develop advanced vehicles, like this hybrid-electric demonstration bus that operates quietly and with extremely low emissions.

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**... 35%–60% of NREL's funding has gone to U.S. industry and universities each year since the Laboratory opened.**

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NREL has a history of working closely with renewable energy and energy efficiency industries. Following the principles outlined for the Laboratory when it was conceived,<sup>10</sup> 35%–60% of NREL's funding has gone to U.S. industry and universities each year since the

Laboratory opened. NREL partners with companies to help with short-term technical problems and to provide long-term technical advances. Persons from U.S. industry serve on technical review panels at NREL, provide guidance to program plans, and work at NREL on exchange programs. NREL will continue to strengthen these efforts.

Most of NREL's interactions with universities are in areas of basic research. But for the 1996 Summer Olympics in Atlanta, NREL and DOE worked with Georgia Tech, Solarex, and Heliocol to showcase photovoltaic panels for electricity (center) and solar collectors for pool heating (left and right roof edges) atop the Georgia Tech Aquatic Center. (Photo - Heliocol)

NREL also continues to work closely with the academic community. In 1995, the Laboratory had formal research subcontracts with 58 different U.S. universities and colleges, involving hundreds of faculty and students, besides the many less formal partnerships that occur among scientific professionals. The basic science that underpins advances in renewable energy provides a fertile and exciting field for the education of future scientists. Expanded partnerships with universities will allow the Laboratory to strengthen its basic science activities and to broaden its technology base into related technologies. To further these partnerships, NREL will increase the number of sabbatical visitors from universities to NREL; in turn, the universities and their centers of excellence will benefit from more interactions with NREL researchers.

Energy efficiency and renewable energy technologies provide valuable solutions for state and local governments. NREL provides analytical information for states, educates state legislators about these technologies, and provides relevant information, such as studies on industrial ecology. The current trend toward decentralization of governmental functions is expected to continue. NREL plans to maintain its partnerships with state and local government entities, and will segment and target audiences within these venues as appropriate.

Partnerships with the financial and business community and end users, such as utilities and consumers, help with project implementation and improve understanding of the economic and institutional considerations in technology development. One of the specific activities that NREL intends to expand is sponsorship of Enterprise Growth Forums, which are periodic meetings between venture capitalists, others from the financial community, and private companies focused on energy efficiency or renewable energy. The forums strengthen relationships between renewable energy entrepreneurs and the financial community and help companies find new investors. Another area of emphasis will be a national network of business incubators for new companies doing work related to energy efficiency and renewable energy, to help these firms tap the Laboratory's information, expertise, and facilities.

Partnerships with states and local communities, the business community, and utilities are vital for both NREL and its partners. NREL worked with such partners in Burlington, Vermont, to assist this 50-MW electrical generating station that uses wood fuel. (Photo - Burlington Electric Department)

The most rapidly growing markets for many renewable energy technologies today are overseas. In

NREL must continue developing relationships with other countries to support U.S. industry's role in developing renewable energy technologies, illustrated here by a wind turbine in a modern city in Brazil. (Photo - Roger Taylor, NREL)

1995, 82% of the worldwide photovoltaics market and 97% of the total worldwide wind turbine market were installed outside the United States. The U. S. renewable energy industry must capture a significant share of these international markets to be viable. Current U.S. energy policies strongly support partnerships with the international community; the National Energy Policy Plan states: "In working toward sustainable international energy development, the Administration will encourage continued improvement of alternative energy and energy-efficiency technologies; worldwide use of U.S. energy technologies; broad dissemination of environmental technologies; and strong partnerships with energy officials around the world." <sup>11</sup> To fulfill its mission, the Laboratory must understand real market needs—especially international markets—and the resultant impacts on technology development. To do this, NREL must continue developing relationships with other governments, agencies, and nongovernmental organizations, in ways that will support U.S. industry's role in developing international business in these technologies. NREL has two centers, Business Ventures and Market Partnerships, and an active international group that is tied to laboratory programs to support this important effort.

#### ***Strategy 4: Increase leveraging of EE funding***

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**To fulfill its mission, the Laboratory must understand real market needs—especially international markets—and the resultant impacts on technology development.**

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DOE encourages leveraging in its vision for its laboratories;<sup>12</sup> Secretary O'Leary's FY 1996 performance agreement directs the DOE laboratories to "enhance the Department's research impact through partnerships with industry and increase the amount of research performed for and with other government

agencies and the private sector."<sup>13</sup>

NREL recognizes the value of leveraging DOE support for the Laboratory with non-DOE revenue sources. When consistent with DOE policy and in support of our mission, leveraging EE funding brings important benefits to NREL and DOE. Leveraging the public investment with private funds results in

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**Leveraging revenue sources allows NREL to work on projects that help to broaden NREL's technical knowledge in ways that can contribute directly to EE's primary mission.**

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more mission-related progress than could be supported using only public investments—critically important as the nation strives for deficit reduction. Developing leveraged projects with industry inherently serves as a technology transfer and commercialization venue, increasing economic growth, jobs, and

technological innovation. Leveraging revenue sources allows NREL to work on projects that help to broaden NREL's technical knowledge in ways that can contribute directly to EE's primary mission. Finally, the financial commitment by a non-DOE customer assures Congress and the American taxpayers that the market places a value on the work being performed and the public investment being made.

NREL's expertise in alternative financing for energy projects helps government agencies save money and energy; an example is passive solar employee housing in Yosemite National Park. (Photo - Nancy Carlisle, NREL)

NREL is participating with other laboratories in a study on "Innovative Financing for R&D," led by DOE. This study is examining the many ways in which R&D in the public interest can be, and has been, supported or leveraged financially with lower levels of direct appropriations.

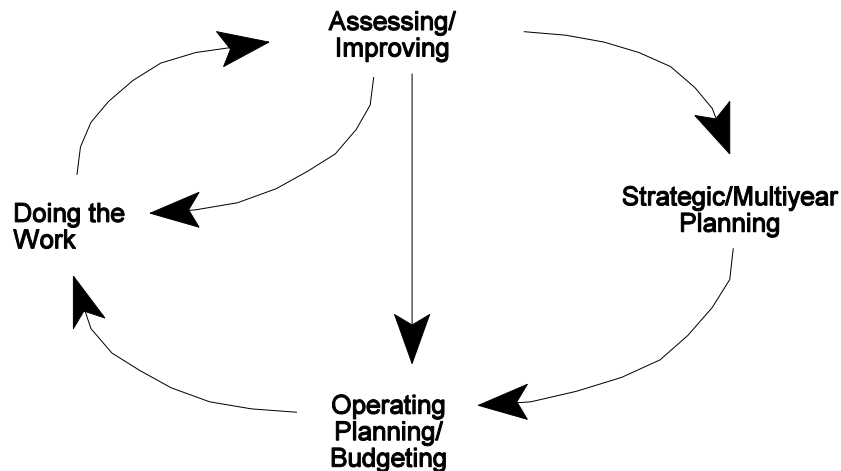
Leveraging EE funding is not a new concept at NREL; currently, about 5% of NREL's funds come from non-EE sources, including DOE's Office of Energy Research (ER), the National Aeronautics and Space Administration, and some private companies. NREL is contributing information on its experiences to the overall group, and is working on a subgroup exploring public and private joint R&D ventures. NREL will use the results of the broad study to explore new ways to leverage EE funding.

As an example of additional activities to leverage EE funds, NREL is considering offering materials and device characterization expertise and services using its state-of-the-art instrumentation, expertise in providing analyses of photovoltaics and electronics materials, and expertise in developing new specialized techniques and instrumentation. In another area, NREL is considering a new initiative to model the relationships between local climate and renewable energy resource availability and use. Also, NREL is considering ways in which its expertise in alternative financing (developing contracts for energy-related projects in which the contractor is repaid by the energy savings generated by the project) for energy efficiency and renewable energy projects can be applied to a wide range of energy projects.

NREL is also working to streamline its process for handling the administration of projects funded by non-EE sources. A faster, more efficient process would make NREL more effective at solving short-term problems for many different types of customers.

# Performance-Based Management

NREL is now completing implementation of performance-based management, an approach that stresses quantitative goal setting and measurement of performance for improved results. Goal setting and measurement of performance are linked from the corporate level to the center level and then to each team and individual, so that each individual understands and appreciates the contribution she or he is making toward the success of the Laboratory.



NREL is using an approach called a "balanced scorecard"<sup>14</sup> to track Laboratory performance and progress toward its strategies, which includes performance measures from four different perspectives: customer, innovation, financial, and internal. NREL's corporate balanced scorecard includes all of the performance measures listed in the following table, and some other in-house measures. Besides the corporate performance measures, each center and many individual teams have developed their own balanced scorecards that support appropriate corporate goals and highlight additional goals specific to their work. These measures and targets are used to periodically assess progress for individuals, teams, centers, NREL management, and MRI.

Selected measures and targets NREL has chosen to track its progress in each of the four strategies are shown in the following table, and are discussed in the notes at the end of the table. NREL has used some of the measures in the past, in which case measurement methodologies have been established and historical data are available. Other measures have not been made before, so NREL is in the process of developing measurement methodologies and developing baseline data. The measures and targets are intended primarily for NREL's internal use, not as a mechanism for comparing the Laboratory to other laboratories or organizations.

Selected NREL Performance Measures and Targets				
	Performance Measures	FY 1995 Actual	FY 1996 Actual	FY 1997 Preliminary Target
<b>Strategy 1: Expand NREL's capabilities for research, development, and deployment assistance for DOE</b>				
	Customer Satisfaction		Draft approach completed	Develop baseline
	Successful Proposals Made		1 accepted for every 4.5 submitted	10% improvement
<b>Strategy 2: Support science and technology with world-class operations</b>				
	Direct Labor Cost Multiplier (See notes for explanation of number pairs)	2.40 3.40	2.21 3.21	2.00 3.00
	Average Operating Cost per Research Full-Time Equivalent Employee	\$173,000	\$166,600	\$160,200
	NREL Technical and Scientific Advances Adopted by Industry		Working on methodology	10% improvement
	Employee Satisfaction		Pilot method completed	Develop baseline
	External Recognitions of Quality of Our People		35	40
	All NREL Individual Performance (measured by 360 degree review)		Working on methodology	Complete development of methodology
	Project Management Quality Ratio		Methodology developed	100%
	Minimize Injuries and Illnesses OSHA Recordable Injury/Illness Rate (number per 100 employees)	2.5	1.2	2.4
	Avoidable Injuries (number)	12	4	5
	Scientific and Technological Impact Rate	56.7	47.7	52.5
	Revenue from Innovative Projects		Working on methodology	10% improvement
<b>Strategy 3: Strengthen integration of NREL's work with others through partnerships</b>				
	NREL Technical and Scientific Advances Adopted by Industry		Working on methodology	10% improvement
	Active Alliances		40, totalling \$5.3 million	44, totalling \$5.8 million



Selected NREL Performance Measures and Targets				
	Performance Measures	FY 1995 Actual	FY 1996 Actual	FY 1997 Preliminary Target
	Customer Satisfaction		Draft approach completed	Develop baseline
<b>Strategy 4: Increase leveraging of DOE/EE funding</b>				
	Revenue Source Diversity	8.8%	6.0%	6.6%
	Customer Satisfaction		Draft approach completed	Develop baseline
	Successful Proposals Made		1 accepted for every 4.5 submitted	10% improvement
	Revenue from Innovative Projects		Working on methodology	10% improvement

**Notes:**

**Customer Satisfaction:** Methods for measuring NREL customer satisfaction are being developed, and may include written, telephone, and face-to-face information gathering efforts by the Laboratory.

**Successful Proposals Made:** Methods for measurement include counting the number of proposals written and submitted to all potential customers, DOE and non-DOE; the number of proposals resulting in funding authorizations or legally binding contracts; and the dollar amount of the new proposals.

**Direct Labor Cost Multiplier:** This is a measure of the total cost of research. The lower number is a factor by which researchers multiply each direct labor dollar to approximate the added non-labor costs of research and the costs of administration and research support; the larger number is the same factor that can simply be used to multiply each direct labor dollar to approximate the total cost of their effort before fees for materials and subcontracts. Because of the variability of accounting methods among R&D institutions, NREL uses this measure to monitor its own progress over time, not to compare itself to other institutions.

**Average Operating Cost per Research Full-Time Equivalent Employee:** This is an alternative "overhead" efficiency measurement, to reflect the operating cost of managing the Laboratory relative to all research full-time equivalent employees.

**NREL Technical and Scientific Advances Adopted by Industry:** Recognizing that NREL technology must be adopted and used by industry to make a difference in reaching our vision of a sustainable energy future, this metric is intended to measure in absolute terms the number of ideas,

techniques, products, or services developed or improved at NREL that have subsequently been adopted by the commercial sector or otherwise put into practice outside our Laboratory.

**Employee Satisfaction:** Deep personal and team-based revitalization and increased satisfaction are necessary ingredients in achieving high performance. This measure will be used to increase the understanding of our mission and the satisfaction felt from every employee in achieving the mission, and align our organizational elements toward achieving our mission.

**External Recognition of Quality of Our People:** As a world leader in science and technology, NREL has, and must continue to have, many staff members who are internationally known in their fields. This measure counts the total number of external recognitions such as memberships in national academies, fellowships in professional societies, and other significant national and international awards in science, technology, and support functions for leadership or excellence.

**All NREL Individual Performance:** NREL is in the process of developing a 360-degree Performance Evaluation Plan, based on using multiple sources of performance feedback.

**Project Management Quality Ratio:** This measure indicates the ratio of projects that meet a quality standard (defined as being completed on time, and on budget, and meeting quality specifications as agreed upon by the center director, the technology manager, and the project manager) to the total number of projects scheduled to be completed during the fiscal year.

**Minimize Injuries and Illnesses:** This measure has two components that together demonstrate a proactive approach to the well-being of our people and reflect the most likely measurable positive impact on lives. The Occupational Safety and Health Administration Recordable Injury/Illness Rate is the number of recordable injuries and illnesses per 100 employees. Avoidable injuries is the total annual number of those injuries and illnesses that could have been avoided had proactive measures been properly implemented.

**Scientific and Technological Impact:** This measure indicates the extent of participation in, and impact upon, the scientific and technical community. It is currently calculated by summing the numbers of specific types of technical documents published plus actions related to patents, per 100 payrolled researchers.

**Revenue from Innovation:** To be successful over the long run, NREL must continuously generate, and develop to the point of revenue generation, new ideas and innovations. It is calculated as the percentage of total Lab revenue that comes from programs or projects that are less than 3 years old.

**Active Alliances:** Active alliances are the total number of written agreements that have been funded or that have had costs expended during the year that result in funding, add a significant capability or capacity, or result in significant contributions to NREL's mission. It is currently calculated by summing licenses, cooperative research and development agreements, and work-for-others agreements signed during the fiscal year. The total dollars may represent efforts expected to extend over several years.

**Revenue Source Diversity:** This is a measure of our ability to leverage EE funds with non-EE funds. It is calculated as operating revenue (budget authority) from non-EE sources as a percentage of total Laboratory operating revenue (budget authority).

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